Quantification of fine sediment retention in the Rhine delta using a two-dimensional floodplain sedimentation model

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1. Introduction

The embanked floodplains along the lower River Rhine distributaries in the Netherlands (Fig. 1) act as a prominent sink for fine sediments and associated pollutants. Current river management for the lower River Rhine focuses on enhancing the discharge capacity and biodiversity of the floodplain areas. There is no doubt that the different landscaping measures being proposed or implemented to fulfill these objectives have a significant impact on the morphological and hydraulic conditions and, therefore, on the sediment trapping potential of the floodplains. To assess the effects of these measures on sediment transport and retention in the lower Rhine floodplains, detailed quantification of the sediment deposition rates and patterns is needed.

2. Methods

To quantify contemporary sedimentation rates and patterns on the floodplains along the main branches of the River Rhine in the Netherlands (total surface area = 399 km^2), a two-dimensional floodplain sedimentation model was adopted at the scale of the entire Rhine delta. This model consists of two components:

1) the hydrodynamic WAQUA model that simulates the two-dimensional water flow patterns and
2) the SEDIFLUX model that simulates sediment transport and deposition.

The model was run for 13 steady state discharge stages between 3500 m^3 s^{-1} and 16000 m^3 s^{-1} at Lobith near the German-Dutch border. Model parameter values of sediment settling velocity (6.7 10^{-5} m s^{-1}) and critical bed shear stress for sedimentation (2.0 N m^{-2}) were assigned based on previous modelling studies. The annual average sediment deposition rates were calculated using the discharge frequency distribution for a period and a sediment rating curve (Fig. 2).

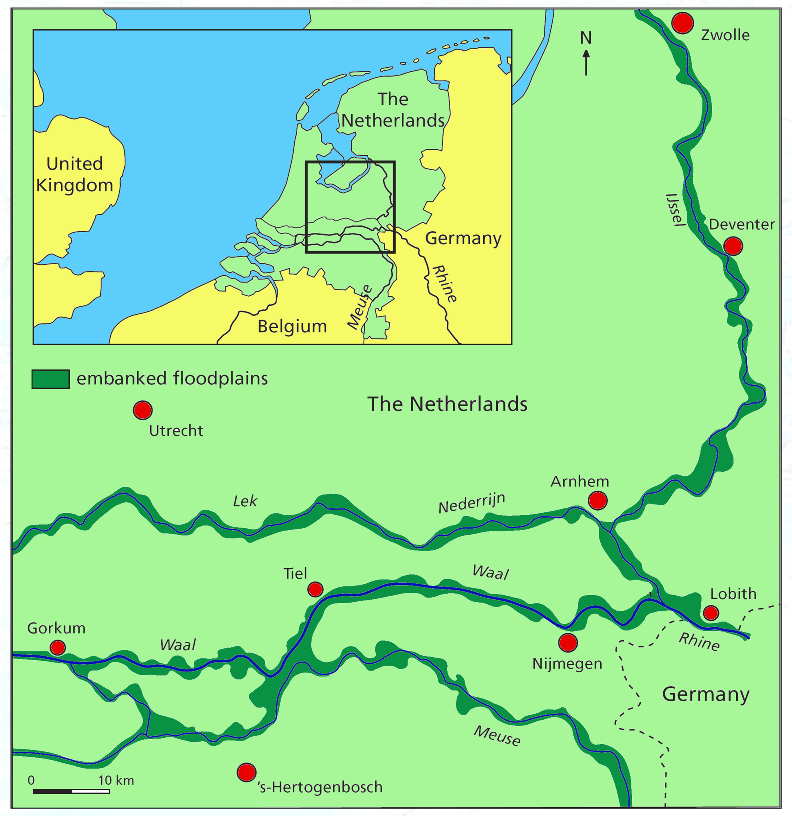


Fig. 1 Location of the model area

3. Results and discussion

Figure 3 shows the spatial pattern of annual average accumulation rate of fine sediments on the floodplains along the Rhine branches in the Netherlands. The average annual accumulation rate is 1.91 kg m^{-2} y^{-1} or 610 million kg yr^{-1}. This corresponds to a conveyance loss rate of 44% for discharges greater than 3500 m^3 s^{-1} and 25% of the total annual suspended sediment load (Fig. 4). These numbers are greater than those previously reported for lower River Rhine floodplains (Asselman and Van Wijngaarden 2001; Thonon 2006), which can largely be attributed to the fact that this study also considered sediment deposition at discharges less than 5000 m^3 s^{-1}. However, a large proportion of the sediment at the lower discharge stages is deposited in areas where the bed shear stress exceeds 2 N m^{-2} once a year on average (total 157 million kg y^{-1}). Therefore, it is likely that part of this sediment is resuspended and transported downstream during annual flood events.

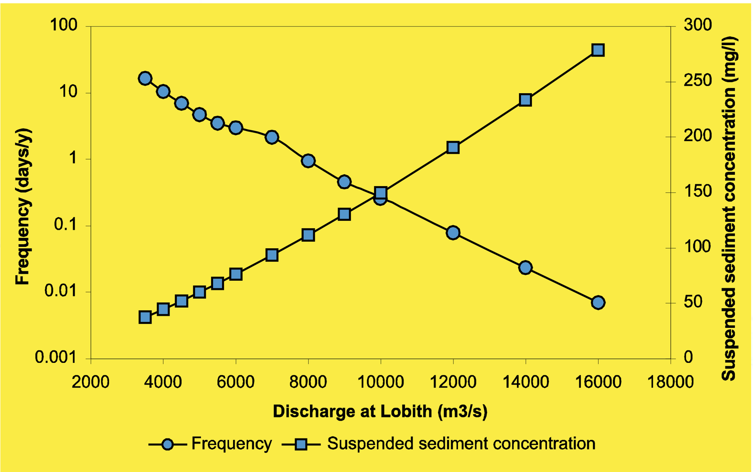


Fig. 2 Discharge frequency (1901-2000) and sediment rating curve (1970-2006) for the River Rhine at Lobith

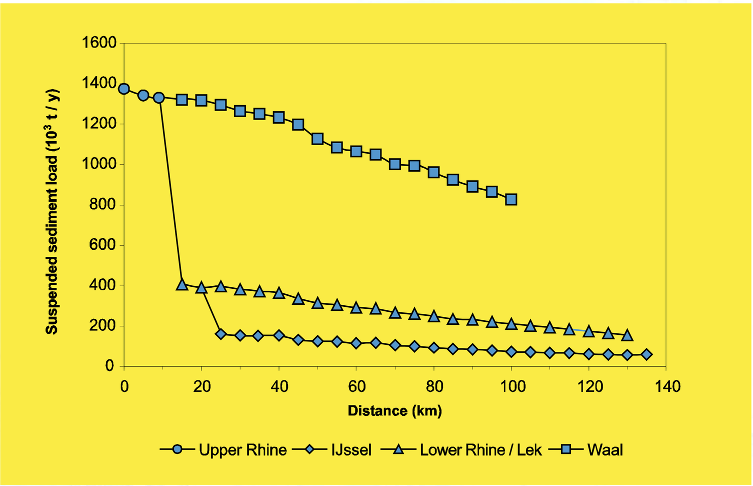


Fig. 4 Longitudinal profiles of sediment load in the River Rhine branches

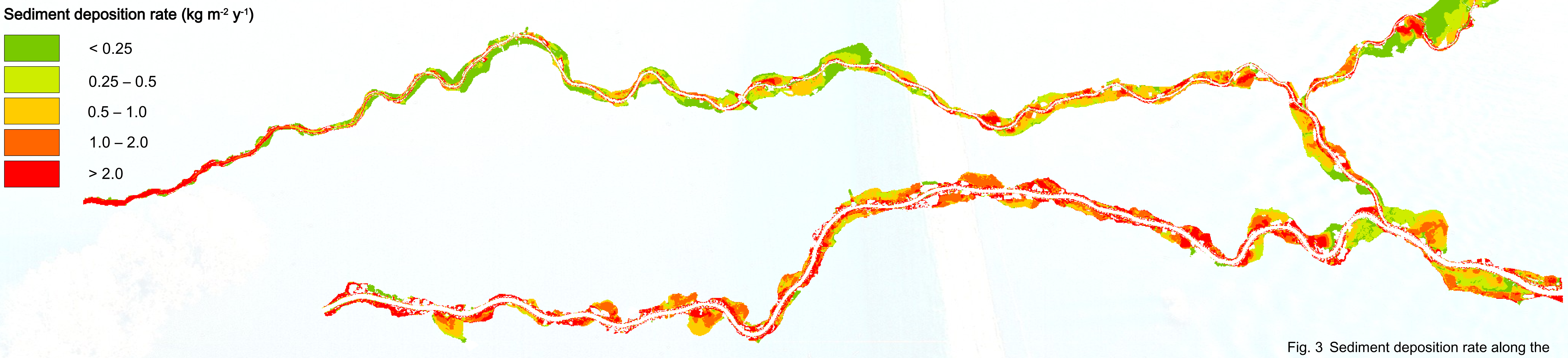
4. Conclusions

- The embanked floodplains along the River Rhine in the Netherlands trap 610 million kg of suspended sediment annually.
- About 25% of the sediment is deposited in areas where it is likely susceptible to resuspension during high discharge.
- To improve the estimation of sediment retention rates in floodplain areas, it is necessary to quantify resuspension of fine sediments from the river bottom and banks.

References

Asselman, N.E.M., and M. van Wijngaarden, 2002. Development and application of a 1D floodplain sedimentation model for the River Rhine in the Netherlands. *J. Hydrol.* **268**:127–142.

Thonon, I., 2006. Deposition of sediment and associated heavy metals on floodplains. Utrecht: KNAG/Faculty of Geosciences, Utrecht University. *Netherlands Geographical Studies* **337**.



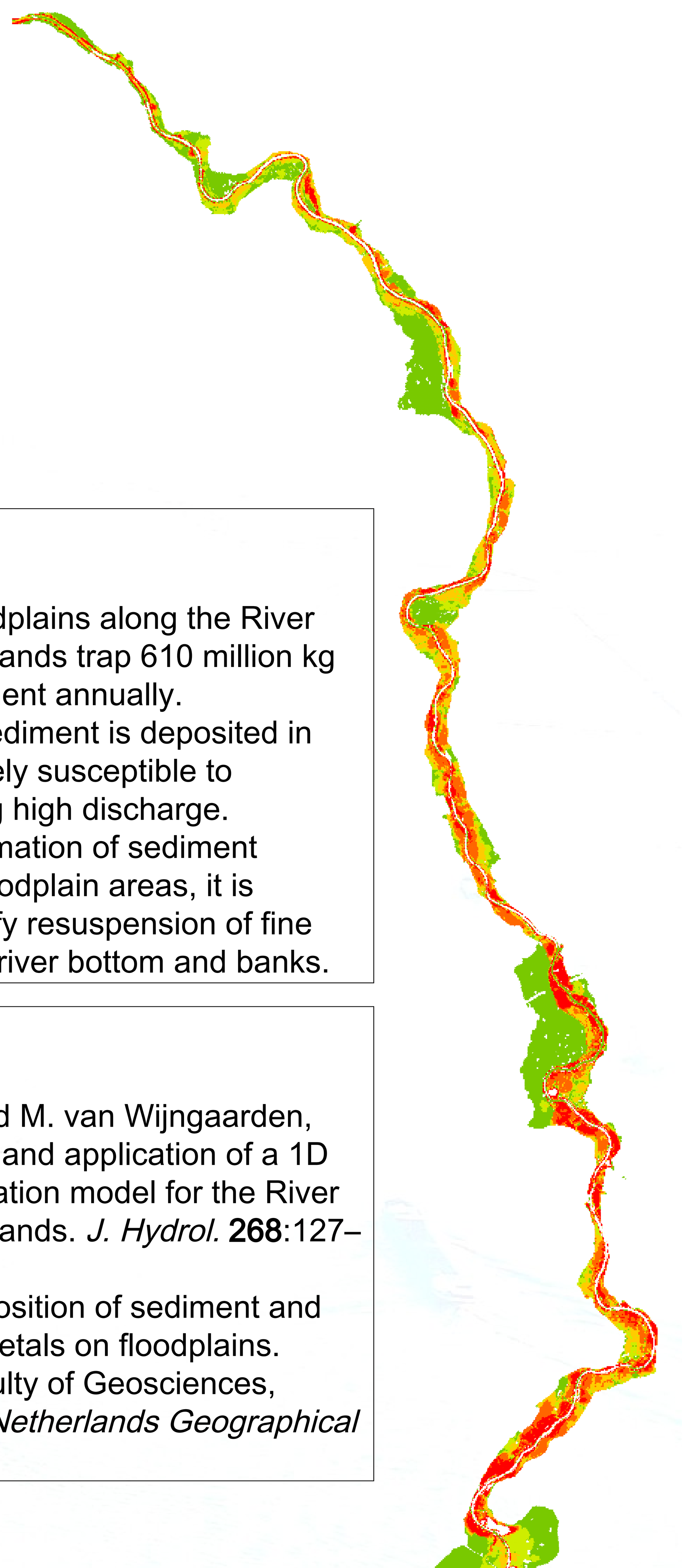


Fig. 3 Sediment deposition rate along the River Rhine branches